

## Naval Facilities Engineering Command Ergonomics Risk Assessment Hull Repair

### Introduction

An ergonomics risk assessment was conducted on October 23rd, 2007. The hull repair operation was observed in order to determine sources of ergonomics stress and recommend improvements. This assessment is based upon interviews with employees and safety personnel as well as an evaluation by a Certified Professional Ergonomist with the Naval Facilities Engineering Command (NAVFACENGCOM) Mishap Prevention and Hazard Abatement (MPHA) program.

The risk assessment was conducted in conjunction with the Job Requirements and Physical Demands Survey (JR/PD). The JR/PD is an ergonomics survey designed to assess ergonomics risk in the workplace. The results of the JR/PD indicate the hull repair operation is an ergonomics problem area with a score of **seven** on a scale of 1 to 9 where 9 is a maximum value. The JR/PD assesses five distinct body regions: shoulder/neck, hand/wrist/arm, back/torso, legs/feet, and head/eyes. The shoulder/neck, back/torso, and leg/feet regions were found to have significant ergonomics risk. Ergonomics risk is based upon ergonomics stressors associated with the task and employee discomfort. Forty-one percent of the survey respondents have seen a health care provider within the last twelve months for pain or discomfort that he or she feels is related to the job. A significant number of employees also reported pre-existing Musculoskeletal Disorders (MSDs) which places them at a higher risk of additional or more severe Work-Related Musculoskeletal Disorders (WMSDs). A significant number of employees reported experiencing work-related pain or discomfort that does not improve when away from work overnight or over the weekend and has caused difficulty in carrying out normal activities. Appendix I contains a summary of the JR/PD results as well as a description of the methodology.

The operation reviewed presents opportunities to reduce the risk of work-related musculoskeletal disorders (WMSDs). Musculoskeletal Disorders (MSDs) are injuries and illnesses that affect muscles, nerves, tendons, ligaments, joints, spinal discs, skin, subcutaneous tissues, blood vessels, and bones. Work-Related Musculoskeletal Disorders (WMSDs) are:

- ∞ Musculoskeletal disorders to which the work environment and the performance of work contribute significantly or
- ∞ Musculoskeletal disorders that are aggravated or prolonged by working conditions.

Recommendations for the command to reduce the probability of injury include equipment purchase<sup>i</sup>, process redesign, and implementation of administrative controls<sup>ii</sup>. Representative vendor information is included in the recommendations to assist in the

evaluation of products and services<sup>iii</sup>. Recommendations for the command include gathering input from the workers, safety specialists, and other personnel to evaluate equipment before purchasing. This process will increase product acceptance, test product usability and durability, and take advantage of employee experience.

Naval Facilities Engineering Command (NAVFACENGCOM) manages the Chief of Naval Operations (CNO) Mishap Prevention and Hazard Abatement Program, which is a centrally managed fund to correct safety and health deficiencies beyond the funding capabilities of the activity. Information about the MPHA program can be found on the Naval Facilities Engineering Command web site [www.navfac.navy.mil/safety](http://www.navfac.navy.mil/safety) and in OPNAVINST 5100.23G chapter 12 Hazard Abatement. The submission deadline for FY09 is March 31<sup>st</sup>, 2008.

## Hull Repair

Purpose of the Operation: Hull Technicians are responsible for repairing and modifying hovercraft

Population: 20 Hull Technicians (HTs)

Injury Data: None provided. Seven employees (41%) who completed the Job Requirements and Physical Demands Surveys have seen a health care provider for pain or discomfort that he/she feels is related to the job.

Description of the Operation: Hull Technicians (HTs) perform hovercraft repairs and modifications which require welding and sheet metal fabrication. Most of the repairs are performed directly on the hovercraft but some fabrication is performed in the metal shop. In addition to sustained awkward postures, welding requires frequent heavy lifting and carrying. Accessing the underside of the hovercraft requires HTs to cut out sections of the hull which then have to be welded back into place. Replacing hull sections requires HTs to hold sheet metal in place for it to be welded. HTs can spend up to 8 hours a day working overhead, as shown in figure 1. The underside of the hovercraft is less than 6 feet above the ground which causes the HTs to contort their body to work on it.

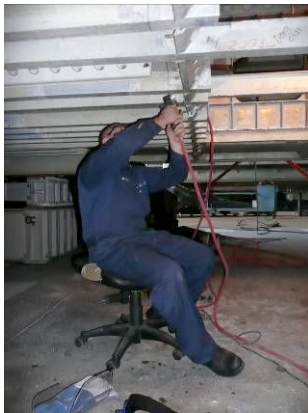


Figure 1: Working overhead

Ergonomics issue description: Hull repair requires awkward sustained postures and heavy force exertions. In addition, workers are exposed to vibration and compression. Physical ergonomics risk factors occurring in combination (e.g. posture, duration, repetition, and force) increase the risk of WMSD development.

**Static Postures:** The employees stand in the machine shop as well as the welding training and testing areas for extended periods. Standing can be a strenuous activity that promotes blood pooling in the legs and feet and can result in discomfort and fatigue. Static postures impede the flow of blood needed by the muscles to supply nutrients and remove the waste products of muscle metabolism. Reduced blood flow

also slows delivery of oxygen to the muscles resulting in a longer recovery time. Waste products, such as lactic acid, can build up in the muscle and cause fatigue. The longer or more frequently static loading occurs, the greater the risk of injury due to overuse of muscles, joints, and other tissues. Leg/Foot discomfort indicated in the JR/PD may be a result of prolonged standing.

**Awkward Postures:** Sailors assume sustained awkward postures during welding operations, particularly when welding in confined spaces. HTs extensively weld overhead which reduces blood flow to the extremities and can strain the shoulders, arms, and torso. The muscles must apply considerably more contraction force to maintain awkward postures. As the duration of the contraction increases, stress on the muscles also rise. The continuous stress on these muscles can lead to fatigue and discomfort which can be precursors to injury. Static awkward postures impede the flow of blood needed by the muscles to supply nutrients and remove the waste products of muscle metabolism. The longer or more frequently static loading occurs, particularly in awkward postures, the greater the risk of injury due to overuse of muscles, joints, and other tissues.

**Heavy lifting:** The workers risk injury from forceful exertions caused by handling components and moving materials such as gas cylinders and sheet metal. HTs support the weight of the sheet metal while retrieving it from storage and then while loading machines. HTs also carry gas cylinders weighing up to 150 lbs. onboard the hovercraft for welding repairs approximately once or twice a month. Forceful exertions can place high loads on the muscles, tendons, ligaments, and joints being used. Increasing the force required to lift a load also means increasing body demands (i.e. greater muscle exertion is necessary to sustain the increased effort) and imposing greater compressive forces on the spine. As force increases, muscles fatigue more quickly. Prolonged or frequent exertions of this type can lead to WMSDs when there is not adequate time for rest or recovery.

**Compression:** Sailors weld while kneeling on concrete, which places biomechanical stress / compression on the knees that can lead to fatigue and discomfort. Hyper-flexing the knees in a squatting or kneeling position can result in pressure on the back of the knees which may reduce circulation in the lower extremities. Worker also rest their elbows while welding which can place stress on nerves and elbow joint.

**Illumination:** Some of the machines in the shop, such as the grinder shown in figure 3, lack sufficient task lighting. Insufficient illumination can increase eye strain and induce awkward postures as workers lean forward to view the task.




Figure 3: Grinder



**Vibration:** Welders use grinders which expose the worker to vibration. The National Institute of Occupational Safety and Health conducted a critical review of epidemiological evidence for work-related musculoskeletal disorders of the neck, upper extremity, and low back. The review found strong evidence of a positive association between high level exposure to hand-arm vibration and vascular symptoms of hand-arm vibration syndrome (HAVS). For example, vibration can result from bad design, poor maintenance, and age of powered hand tools. New powered hand tools can still expose employees to excessive vibration if they do not include devices to dampen the vibration or shield the operator from it. There is substantial scientific evidence that as intensity and duration of exposure to vibrating tools increases so does the risk of developing HAVS.

**Recommendations**


- ∞ Auto-darkening welding helmets may reduce awkward neck motions associated with lowering traditional hoods. The auto-darkening feature also reduces the likelihood of welding without proper eye protection. Refer to vendor table 1.

| <b>Vendor</b>                           | <b>Product</b>                 | <b>Estimated Cost</b> | <b>Figure</b>   |
|---|--------------------------------|-----------------------|---|
| Lab Safety<br>1-800-356-0783            | Auto-darkening welding helmets | \$447-\$486           |  |
| Grainger                                |                                | \$148- \$263          |   |
| Fastenal<br>Chris White<br>919-738-6098 |                                | \$182-\$335           |   |

- ∞ Height adjustable creepers and tool stools would allow the HTs to get closer to underside of the hovercraft and support their back and shoulders. Refer to vendor table 2.


| Vendor                       | Product          | Estimated Cost   | Figure  |
|------------------------------|------------------|--|---|
| Eidos<br>1-800-210-9666      | Ranger Model 117 | Call for pricing.<br>Options include arm rests, foot rests, and tool holders |  |
| Lab Safety<br>1-800-356-0783 | Tool Stools      | \$199  |  |
| C&H<br>1-800-558-9966        |                  | \$156  |   |
| Grainger                     |                  | \$203  |   |



∞ Additional overhead lighting and task lights with variable level and positioning would allow the workers to select the light level appropriate for the task, thus reducing eye strain and awkward postures. Table 3 contains additional information.

| Vendor   | Product   | Price | Photo   |
|----------|---|-------|---|
| Grainger | <b>Tool Light, 100w, 120v</b><br>Heavy Duty Machine Tool Light, Incandescent, 100 Watts, 1285 Lumens, 120 Volts, Overall Reach 37 In, Arm Length 27 In, 360 Degrees Rotation, | \$96  |  |

|   |  |            |   |
|---|--|------------|---|
|   | <p><b>Tool Light,55 W</b><br/>                 Machine Tool Light, Power Rating 55 Watts, Lamp Halogen, Transformer Integrated, Recommended Lamp 4PC98, 10 Inches, Waterproof, Direct Mount with Integrated Transformer</p>  | \$212      |  |
| <p>Lab Safety<br/>                 800-356-0783</p> | <p>LumaPro Fixtures stand firm against heavy vibration<br/>                 Easy attachment to all kind of machine tools<br/>                 Light head base mounts vertically or horizontally<br/>                 Light up your work on lathes, grinders, presses, and assembly and inspection units.</p> | \$75-\$200 |  |


- ∞ Light-weight anti-fatigue matting for the machine shop and welding training area may help reduce fatigue. Portable, light-weight mats could also be used while performing repairs on the hovercraft if the HT is standing or lying in one place. Any matting used around welding needs to be weld-safe. Matting provides a soft, uneven surface that promotes an imperceptible sway which can relieve pressure on the bottom of the foot and aid circulation. Refer to Table 4 for vendor information.
- ∞ Working in confined spaces causes the HTs to sustain awkward postures. Knee pads and elbow pads may help reduce compression causes by pressing against metal surfaces. Refer to vendor table 4.

| <b>Table 4: Matting, Knee, and Elbow Pads</b>               |  |                                       |   |
|---|--|---------------------------------------|---|
| <b>Vendor</b>   | <b>Product</b>   | <b>Price</b>                          | <b>Photo</b>  |
| <p>Cessi Ergonomics<br/>                 1-800-Buy-Ergo</p> | <p>Anti-fatigue matting<br/>                 Most vendors will send you a sample. Matting is</p> | <p>Matting prices depend on size.</p> |  |



|   |   |           |   |
|---|---|-----------|---|
| Fastenal<br>Chris White<br>919-738-6098 | very subjective and it is a good idea to let your employees try it. Grid matting is easy to clean. Look for a vendor with a warranty. |           |   |
| Ergomat<br>1-800-357-2111               |   |           |   |
| Peaklogix<br>703-819-6061               | Flame retardant "Weldsafe Mat" 2' x 3' with beveled edge  | \$39      |    |
| C&H Distributors<br>1-800-558-9966      | Portable anti-fatigue mat   | \$49      |   |
| Alimed<br>1-800-225-2610                |   | \$13      |   |
| Lab Safety<br>1-800-356-0783            | Knee pads   | \$16      |   |
| Grainger                                |   | \$10-\$36 |   |
| Alimed<br>1-800-225-2610                |   | \$66      |   |
| Lab Safety<br>1-800-356-0783            | Elbow pads  | \$14-\$25 |  |

∞ Gas cylinders could be transported onboard the hovercraft by crane to reduce heavy carrying. Gas Welding and Cutting 29 CFR 1926.350 and the Construction Safety and Health Outreach Program [www.osha.gov/doc/outreachtraining/htmlfiles/welding.html](http://www.osha.gov/doc/outreachtraining/htmlfiles/welding.html) address safe movement of gas cylinders. Refer to vendor table 5 for product information.




| <b>Table 5: Gas Cylinder Transport</b> |  |              |   |
|--|--|--------------|---|
| <b>Vendor</b>                          | <b>Product</b>   | <b>Price</b> | <b>Photo</b>  |
| Clegg Company<br><br>1-866-569-8801    | Gas Cylinder Crane Cage<br>HRCT30x30<br>34"Wx34"Dx84"Tall<br>Ratchet strap to hold bottles<br><br>Conforms to OSHA guidelines for lift equipment | \$2,315      |  |

∞ A modified transmission jack or sheetrock holder could be used to position sheets of metal during welding so the HTs don't have to have them in place. Refer to vendor table 6 for product information.



| <b>Table 6: Sheet Metal Positioner</b>  |  |              |   |
|---|--|--------------|---|
| <b>Vendor</b>                           | <b>Product</b>   | <b>Price</b> | <b>Photo</b>  |
| LK Goodwin<br><br>1-800-343-2478        | Lightweight, Portable Material Lift Powered by CO2 or Compressed Air | \$1,675      |   |
| Gilmore Kramer<br><br>1-800-544-3137    |  |              |   |
| Fastenal<br>Chris White<br>919-738-6098 | ½ Ton Single Speed Telescopic Transmission Jack                      | \$880        |  |
| Grainger                                |  |              |   |

∞ Height adjustable scissor lift carts can be lowered to the height of sheet metal storage and raised to the height of a machine for loading. Scissor lift carts can reduce heavy lifting and promote neutral work postures. Refer to vendor table 7.

| <b>Table 7: Scissor Lift Carts</b> |  |              |              |
|------------------------------------|--|--------------|--------------|
| <b>Vendor</b>                      | <b>Product</b>                                 | <b>Price</b> | <b>Photo</b> |
| Grainger                           | Manual Hydraulic Lift Cart, Load Capacity 1000 | \$812        |              |

|   |  |        |   |
|---|--|--------|---|
|   | Pounds, Platform Length 63 Inches, Platform Width 32 Inches, Raised Height 36 Inches, Lowered Height 11 1/4 Inches, Caster Size 5 Inches, Single Speed Foot Pump, Elevating Scissors |        |  |
| Fastenal<br>Chris White<br>919-738-6098 | 30" x 60" 3000lb Cap<br>Electric Hydraulic Scissor<br>Lift Table   | \$2770 |   |

∞ Lower vibration tooling and vibration lowering gloves can help reduce vibration exposure. Only full-fingered gloves that conform to ISO 10819 Standard should be considered. Refer to vendor table 8 for more information.

| Vendor                                     | Product                   | Price                       | Photo   |
|--|---------------------------|-----------------------------|---|
| Impacto<br>Air Glove<br>1-888-232-0031     | Vibration Reducing Gloves | Pricing depends on quantity |   |
| Ergodyne<br>Proflex<br>1-800-225-8238      |                           |                             |   |
| Chase<br>Ergonomics<br>1-800-621-5436      |                           |                             |   |
| Atlas Copco<br>800 654 5965                | Low vibration tooling     | Price depends on tool       |  |
| Honsa Tools<br>Phil Chabot<br>309-781-3059 |                           |                             |   |
| Fastenal<br>Chris White<br>919-738-6098    |                           |                             |   |

∞ Encourage workers to take stretching breaks during the day to relieve discomfort and encourage muscle movement<sup>2</sup>. Micro-breaks taken throughout the day can aide in muscle recovery. The following web sites include exercises that can be

printed and posted. Sources should be cited when reproducing information.  
Web site links updated November 2007.

<http://www.steelcase.com/na/knowledgedesign.aspx?f=10250&c=10213>  
<http://www.safety.duke.edu/Ergonomics/Stretch/90Seconds.htm>  
[www.shelterpub.com/fitness/office\\_fitness\\_clinic/OFC\\_online\\_stretches.html](http://www.shelterpub.com/fitness/office_fitness_clinic/OFC_online_stretches.html)



**Appendix I**  
**Job Requirements and Physical Demands Survey Results**  
**Hull Repair**

**Summary**

The Job Requirements and Physical Demands Survey (JR/PD) was administered

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End Notes:

<sup>i</sup> Equipment purchase without proper and repeated training will not mitigate risk and may in fact increase hazards.

<sup>ii</sup> Administrative controls are management-controlled work practices and policies designed to reduce exposures to work-related musculoskeletal disorders (WMSDs) hazards by changing the way work is assigned or scheduled. Administrative controls reduce the exposure to ergonomic stressors and thus reduce the cumulative dose to any one worker. Examples of administrative controls that are used in the ergonomics context are employee rotation, employer-authorized changes in the pace of work and team lifting.

<sup>iii</sup> This report does not constitute an endorsement of any particular product. Rather, it is a recitation of how Navy personnel have addressed a particular work place safety issue. Neither the Navy nor its employees and agents, warrant any product described in this report for any use, either general or particular.